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(54) Abstract Title
Method of adjusting the gain of an amplifier in a mobile phone to keep the audio output below a maximum pain threshold and above a minimum audible threshold

(57) To prevent the production of an acoustic signal (23) with an excessively high level in the vicinity of the ear when the hands-free function of a mobile telephone (1) has been activated in compensation for the attenuation of an audio signal, an increase in the level of the audio signal beyond a pain threshold (MAX THRESHOLD) is detected, and the level of this audio signal is adjusted automatically by adjustment of the gain of an analogue volume amplifier and/or an analogue hands-free amplifier. A minimum audibility threshold is also defined. Preferably: the gain is adjusted by first acting on the hands-free volume amplifier which preferably operates in an all-or-nothing mode; the signal is amplified to ensure that volume is above the minimum threshold; the gain elements act subordinate to an activity (i.e. speech) detector. A further preferable feature of the preferred embodiment is 'symmetry' of gain change such that attenuation of a signal exceeding the maximum threshold is performed firstly be negating an immediately prior user varied gain increase.

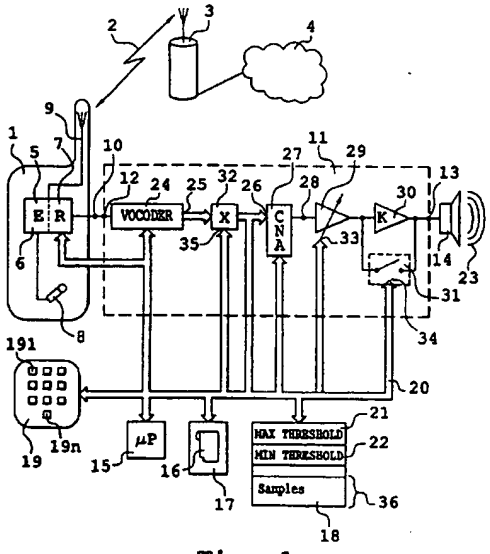

Fig. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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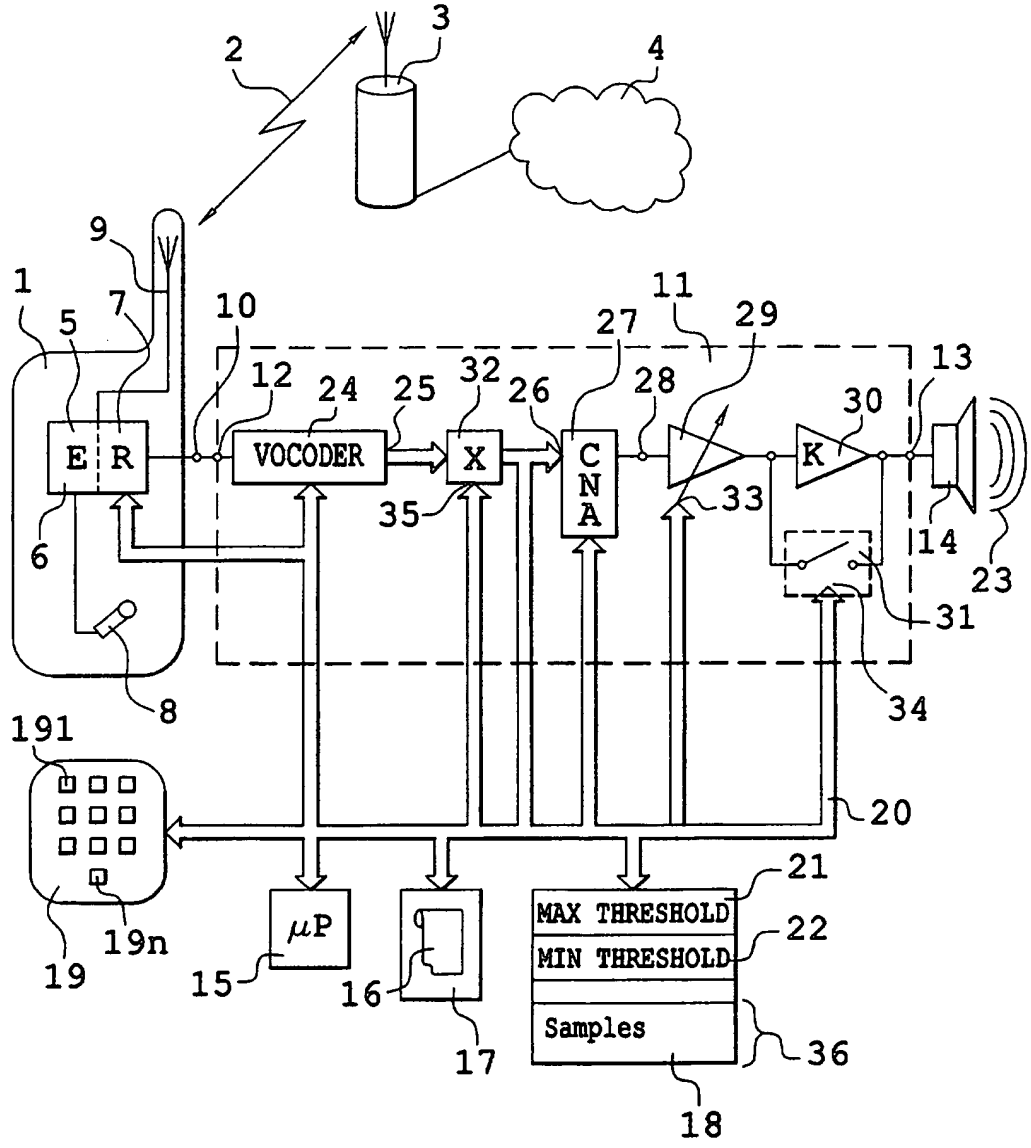
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MIN THRESHOLD
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19n
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16
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Samples
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Fig. 1

METHOD OF ADJUSTING A SOUND LEVEL IN A MOBILE TELEPHONE

An object of the present invention is a method for adjusting a sound level in a mobile telephone. This invention can be applied more particularly to a mobile telephone provided with a hands-free function. The hands-free function in a mobile telephone corresponds to the possibility of engaging in dialogue by means of a telephone without having the telephone close to the ear. This possibility implies the use of amplification means that are capable of increasing the sound level of an acoustic signal beyond a maximum sound level associated with a normal use of the telephone. A normal use, during a conversation, corresponds to the use of the telephone close to the ear.

The term « level » is understood to mean a value by which a signal can be quantified. Thus, the use of an expression such as "the sound level », for example, designates both an amplitude associated with a corresponding acoustic signal and a power value of this signal. However, in ambiguous instances, the appropriate term, such as amplitude or power, will be used instead of the term « level ».

At present, when a sound level of an acoustic signal is below a threshold of audibility or when it is simply low, a user of the mobile telephone increases an amplification gain of this sound signal by using, for this purpose, commands associated with the adjustment of the volume. When this sound level is below the threshold of audibility and when the mobile telephone is provided with a hands-free function, then the user can activate the hands-free function in order to achieve the maximum amplification of the corresponding sound signal. In this case, the sound level is sufficient for the associated signal to become audible.

This facility of adjustment raises problems. Indeed, when the user has activated the hands-free function in order to achieve the maximum amplification of a whisper type of signal, it may happen that this signal will take a sound level above the threshold of audibility. In this case, if the hands-free function of the mobile telephone is activated and if the loudspeaker of the mobile telephone is close to the user's ear, then the sound level close to the ear may be far higher than pain threshold. This causes hearing difficulties in varying degrees of gravity for the user.

It is an object of the present invention to overcome these problems by

proposing a method for the automatic adjusting of the sound level before it crosses the pain threshold. Thus when a user adjusts a listening sound level of the mobile telephone to remedy an attenuation of the sound signal then, with the invention, a listening sound level is automatically reduced as soon as the sound level has an amplitude higher than a threshold of maximum intensity defined in the mobile telephone. Thus, the user's ear is prevented from being subjected to harmful effects through a sudden increase in the amplitude of the sound signal broadcast by the loudspeaker of the mobile telephone.

An object of the invention therefore is a method of adjusting a sound level of an acoustic wave, produced by a mobile telephone, by means of an audio transmission channel receiving an audio signal at an input, wherein:

- in the audio channel, there is defined a normal listening range limited, firstly, by a maximum pain threshold and, secondly, by a minimum audibility threshold;

- an acoustic signal is produced by means of a loudspeaker ;

characterized in that :

- a digital-analog converter, a variable gain analog volume amplifier and a hands-free volume amplifier working in all-or-nothing mode are placed in the audio channel;

- after detection of an increase in the amplitude of the audio signal beyond the maximum pain threshold, the amplitude of the acoustic signal is automatically attenuated so as to bring it into the normal listening range by an adjustment of the amplification gain of the audio channel by action on the analog volume amplifier and/or the analog hands-free amplifier.

The present invention will be understood more clearly from the following description and the appended drawing. This drawing is given purely by way of an indication and in no way restricts the scope of the invention. In this drawing:

Figure 1 shows a view of an exemplary architecture of the mobile telephone used to implement the method of the invention.

Figure 1 shows an exemplary architecture of the mobile telephone used to implement the method of the invention. This telephone 1 is linked by an RF wave 2 to a base station 3 of a mobile telephony network 4. The telephone 1 has a sender/receiver device 5 comprising, firstly, a sender 6

and, secondly, a receiver 7. In a simple example, the sender 6 is connected to a microphone 8 by means of intermediate circuits, not shown, such as, for example, an analog-digital converter. The sender 6 and the receiver 7 are connected to an antenna 9 in order to respectively send or receive the wave 2. The invention more particularly concerns the reception part of the wave 2 representing an audio signal, namely a speech signal. Consequently, only the part concerning reception will be explained. Thus, the receiver 7 is responsible for shaping the wave 2 received by the antenna 9 and thus produces an audio signal in digital form at an output 10.

The telephone 1 has, *inter alia*, a transmission channel 11 receiving the audio signal, given at the output 10, at an input 12. This input 12 is connected to the output 10. The channel 11 is responsible for converting the digital audio signal present at the input 12 into an analog type of audio signal at an output 13. The output 13 is furthermore connected to a loudspeaker 14. The channel 11 comprises, *inter alia*, means for adjusting an amplification gain of the audio signal produced at the output 13.

The telephone 1 comprises means for checking and adjusting the device 5 as well as the channel 11. These means are, especially, a microprocessor 15 controlled by a programme 16 in a programme memory 17, a working memory 18, a touchpad 19 comprising control and checking keys 19 1 to 19 n. The device 5, the channel 11 and the elements 15 to 19 are connected by a data, address and control bus 20.

At a location 21, the memory 18 has a value MAX THRESHOLD corresponding to a maximum pain threshold and, at a location 22, it has a value MIN THRESHOLD corresponding to a minimum threshold of audibility. A difference between the value MAX THRESHOLD and the value MIN THRESHOLD defines a normal listening range of an audio signal transmitted through the channel 11. This audio signal, given at the output 13, is applied to the loudspeaker 14 to produce an acoustic signal 23. Thus, when the audio signal at input 12 has an amplitude below the threshold defined by the value MAX THRESHOLD, then action is taken on the touchpad 19 to adjust the amplification gain of the channel 11.

In the invention, when the signal present at the input 12 again becomes higher than the value MIN THRESHOLD, then the programme 16 acts on the amplification gain of the channel 11 through the microprocessor

15 and automatically attenuates an amplitude of the signal 23 to bring it back into the normal listening range. This automatic attenuation is achieved when the programme 16 detects an increase in the amplitude of the audio signal in the channel 11 indicating that the amplitude has crossed the threshold 21.

In a preferred example, the reduction in gain is achieved symmetrically with the increase in gain made by the user of the telephone 1. Thus, if the user has activated the hands-free function and acted on the amplifier 29 then, for the attenuation, the action on the amplifier 29 is eliminated and the hands-free function is deactivated. This makes it possible to retrieve the listening level that was used before the user raised the sound level in response to the initial low level of the audio signal.

Generally, the channel 11 has a decoder 24 or again a vocoder 24 connected by an output 25 to an input 26 of an digital-analog converter 27, the converter 27 producing, at an output 28, an analog signal designed for the loudspeaker 14. Furthermore, a variable-gain analog input amplifier 29, having an input connected to the output 28 of the converter 2, and an analog hands-free amplifier 30, working in all-or-nothing mode, are placed in the channel 11. The amplifier 30 may be represented schematically by a fixed-gain amplifier K, parallel-connected with a switch 31. In this case, when the hands-free function is deactivated, the switch 31 is closed and when the hands-free function is activated, then the switch 31 is open. A signal present at the input of the amplifier 30 is then amplified by the factor K before being applied to the output 3. When the amplifier 30 is short-circuited by the switch 31, then an amplifier with a unit gain is obtained.

However, this is only a schematic representation. Any other means may be used to obtain an amplifier 30 by which the hands-free function can be obtained. The channel 11 may possibly include a digital amplifier 32 placed at output 25 of the vocoder 24. This means that the converter 27 can be provided with samples in digital but amplified form. In a preferred embodiment, this amplifier 32 is a multiplier. It could also, in another example, be a shift register which would thus perform operations of multiplication by two. In this case, the output 25 would be connected to the bus 20, as also the input 26. This multiplier 32 is not unavoidably necessary since the microprocessor 15 can fulfil this function of digital amplification.

Consequently, the adjustment of the amplification gain of the channel

11 is obtained chiefly by the microprocessor 15 in adjusting the amplification 32 and/or the amplification 29 and/or the amplification 30. For this purpose, the amplifiers 29, 30 and 32 comprise a control input 33, 34 and 35 respectively. In a preferred example, these inputs 33 to 35 are digital type inputs. A digital type input is an input receiving digital signals. For this purpose, this type of input is connected to the bus 20 so that the microprocessor 15 can control the amplifier 29 and the amplifier 30 the amplifier 32 with a gain value.

To detect an increase in the amplitude of the audio signal beyond the pain threshold, or below the audibility threshold, a check is carried out for example on an amplitude of a sample. Generally, samples to be converted with the converter 27 are placed in a buffer memory, for example the memory 18. Thus, the memory 18 comprises a group 36 of samples. The microprocessor 15, under the control of the programme 16, checks an amplitude of the samples of the group 36. When the microprocessor 15, following this check, detects samples whose amplitude is greater than the value 21, then it automatically activates an attenuation of the amplification gain of the channel 11. For this purpose, the microprocessor 15 adjusts the amplifier 30 with a unit gain, for example by closing the switch 31, and/or it adjusts the gain of the amplifier 29 until the amplitude of the audio signal again becomes lower than the value 21. In a preferred example, first of all the amplifier 30 is adjusted and then the amplifier 29.

A preferred variant of the invention uses a parameter used by the vocoder 24 to detect any crossing of the value 21. The vocoder 24 works by groups of samples, each group corresponding to a 20-millisecond period of dialogue. Among all the parameters produced by the vocoder 24, there is one in particular that gives an item of information on the level of the audio signal portion present in the vocoder 2. Consequently, when this parameter given by the vocoder 24 has a value corresponding to a crossing, by the samples, of the value MAX THRESHOLD then the microprocessor 15 activates an attenuation of the amplification gain of the channel 11. However, the vocoder 24 could use a parameter equal to the reverse of the energy. In this case, the inequality would get reversed. This parameter is therefore relative to an amplitude of the audio signal to be transmitted to the loudspeaker14.

The advantage of this variant is that it gives an idea of the changes in gain to be applied as early as possible in order to give a system a lengthy response time in which to react. For example, if the vocoder 24 has to inform the microprocessor 15 that the volume is increasing, then this microprocessor 15 must take the information into account, make a few computations if necessary and control the gain matching operation with its response times.

In a preferred embodiment of the invention, the telephone 1 has a means of detecting activity. This means may very well use the microphone 8 as a detector and the microprocessor 15 as an analyzer. Consequently, the microprocessor 15 can know if the user of the telephone 1 is speaking or not. Thus, in this preferred embodiment, the microprocessor 15 automatically detects the fact that the amplitude of the audio signal is below the value MIN THRESHOLD. In this case, the audio signal is amplified by adjusting the amplifiers 29, 30 and 32. However, this amplification is automatically subordinated to a detection of an activity by the detection means. Indeed, an instant of silence should not be interpreted as a drop in the level of the audio signal below the threshold of audibility.

Similarly, the telephone 1 comprises an echo cancellation means. This echo cancellation means can be implemented by means of the microprocessor 15 and the group 36. Generally, this echo cancellation means is associated with a hands-free function. Thus, this cancellation means is activated when the hands-free function is activated also. In this variant, the echo cancellation means is deactivated when the audio signal received at input 12 is below the value 22. Indeed, this means that an activation of the amplifier 30 is not associated with the hands-free function but is used as an amplifier for a highly attenuated audio signal or for an audio signal relating to a whisper.

CLAIMS

1. Method of adjusting a sound level of an acoustic wave (23), produced by a mobile telephone (1), by means of an audio transmission channel (11) receiving an audio signal at an input (12), wherein:

- in the audio channel (11), there is defined a normal listening range limited, firstly, by a maximum pain threshold (MAX THRESHOLD) and, secondly, by a minimum audibility threshold (MIN THRESHOLD);

- an acoustic signal is produced by means of a loudspeaker (14) ;

characterized in that :

- a digital-analog converter (27), a variable gain analog volume amplifier (29) and a hands-free volume amplifier (30) working in all-or-nothing mode are placed in the audio channel (11);

- after detection of an increase in the amplitude of the audio signal beyond the maximum pain threshold (MAX THRESHOLD), an amplitude of the acoustic signal is automatically attenuated so as to bring it into the normal listening range by an adjustment of the amplification gain of the audio channel (11) by action on the analog volume amplifier (29) and/or the analog hands-free amplifier (30).

2. Method according to claim 1, characterized in that :

- a digital amplifier (32) is placed in the audio channel (11) to give the digital converter (27) samples of the amplified audio signal in digital form.

3. Method according to one of the claims 1 or 2, characterized in that :

- the amplification gain of the audio channel (11) is adjusted by acting firstly on the hands-free analog amplifier (30).

4. Method according to one of the claims 1 to 3, characterized in that :

- a decoder (24) connected by an output (25) to an input (26) of the digital-analog converter (27) is placed in the audio channel;

- an increase in the amplitude of the audio signal is detected by comparing the maximum pain threshold (MAX THRESHOLD) with a value of a parameter produced by the decoder and pertaining to an amplitude of the audio signal to be transmitted to the loudspeaker.

5. Method according to one of the claims 1 to 4, characterized in that :

- a means (8) of activity detection is placed in the mobile telephone (1);

- an amplitude is amplified automatically when it is detected that the audio signal has gone below the minimum threshold (MIN THRESHOLD) of audibility ;

- the automatic amplification is subordinated to a detection of an activity by the activity detection means.

6. Method according to one of the claims 1 to 5, characterized in that :

- an echo cancellation means is placed in the mobile telephone, this echo cancellation means being associated with a hands-free function of the mobile telephone (1);

- the echo cancellation means is deactivated when the activation of the hands-free function is associated with a detection of an amplitude of the audio signal below the minimum threshold (MIN THRESHOLD) of audibility.

7. Method according to one of the claims 1 to 6, characterized in that :

- the automatic attenuation is obtained symmetrically to the increase in the amplitude of the audio signal achieved to compensate for its low initial level.

8. Method substantially as hereinbefore described with reference to figure 1 of the drawings.

INVESTOR IN PEOPLE

Application No:	GB 0029330.8	**Examiner:**	Paul Jefferies
Claims searched:	1-8	**Date of search:**	29 June 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H3G (GA, GPA, GPD, GPX)

Int Cl (Ed.7): H03G 3/00, 3/20, 11/00

Other: ONLINE: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	US 5630014	(YOSHIDA et al.) See Abstract and figure 1.	
A	US 5530767	(NEC) See figures 1, 4 and column 4, lines 27 et seq.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.